Hybrid Wood Energy Systems
Breakout Session Summary Report

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Natural Gas /Renewable Energy

Hybrids Workshop

August 8, 2001

Organizations that Participated in the Wood Waste Session

- GE Corporate Research and Development
- Gas Technology Institute
- National Energy Technology Laboratory
- Siemens-Westinghouse Power Corporation
- Tennessee Valley Authority

- twelve people participated

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Scope of Systems Considered

- < 10 MW (200 tons per day)
- must have locational value
- power must be distributed at local voltage
- must use both natural gas and wood fuels

- <u>wood fuels</u> non-herbaceous woody biomass with less than 50% moisture

- coal mine methane could be used instead of natural gas

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Scope of Hybrid Wood Energy Systems that were Considered

- **Applications Considered**
  - Power (only)
  - Process Heat (only)
  - CHP
  - Fuels / Chemicals

- **Technologies Considered**
  - combustion, gasification and pyrolysis
  - gas engines
  - gas turbines, microturbines
  - fuel cells

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Suggested System Configurations

- **Power or CHP**
  - Hybrid Wood Gasification Fuel Cell System
  - Hybrid Wood Gasification Gas Engine / Microturbine System
  - Wood-fired Gas Turbine Preheat System (the Berkshire Cycle)
- **all three were retained for further analysis**

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Suggested System Configurations (continued)

- **Process Heat (only)**
  - using natural gas to enhance the environmental performance of wood-based combustion systems
  - not retained for further analysis

- **Fuels / Chemicals**
  - co-pyrolysis of wood with natural gas
  - these applications are unlikely to be feasible at the scale under consideration (<200 tpd)
  - not retained for further analysis

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#1 Hybrid Wood Gasification Fuel Cell System

- **Wood Conversion**
  - Air-Blown Gasifier
- **Prime Mover(s)**
  - high temperature fuel cell (MCFC or SOFC)
  - various topping / bottoming cycles could be added
- **Role of Wood**
  - gasified to supply fuel gas to the fuel cell
- **Role of Natural Gas**
  - increase & stabilize the BTU value of the wood-derived fuel gas
  - supplement the time-varying supply of wood

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#2 Hybrid Wood Gasification
Gas Engine / Microturbine System

- **Wood Conversion**
  - Air-Blown Gasifier
- **Prime Mover(s)**
  - gas engine
  - various topping / bottoming cycles could be added
- **Role of Wood**
  - gasified to supply fuel gas to the gas engine
- **Role of Natural Gas**
  - increase & stabilize the BTU value of the wood-derived fuel gas
  - supplement the time-varying supply of wood

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#3 Wood-Fired Gas Turbine Preheat System

- **Wood Conversion**
  - Fluidized Bed Combustor-Heat Exchanger
- **Prime Mover(s)**
  - gas turbine
  - various topping / bottoming cycles could be added
- **Role of Wood**
  - combusted in FBC-HX to preheat the compressed turbine inlet air stream
- **Role of Natural Gas**
  - fuel for gas turbine

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Advantages Common to All Configurations

- utilization of a renewable energy resource
  - helps to stabilize global fuel prices, enhances national energy security
  - reduces global greenhouse gas emissions
- a cheap fuel (wood) is substituted for a more expensive fuel
- possibly lower COE

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Advantages Unique to #1 Wood Gasification Fuel Cell

- very high efficiency
- green power
- low emissions
- wood to natural gas fuel ratio is high

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Advantages Unique to #2 Wood Gasif. Gas Engine / Microturbine

- fairly straightforward system
- near-term application; relies on commercial technologies
- less sensitive to composition of wood-derived fuel gas (than fuel cell configuration)
- modest gas cleanup required (compared to the fuel cell configuration)
- concept proven in WW II (under difficult conditions)

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Advantages Unique to #3 Wood-Fired Gas Turbine Preheat System

- highly efficient conversion of wood energy
- minimal gas cleanup requirements (compared to other configurations)
- forgiving of time-varying wood fuel properties & tolerant of a wide range of moisture contents
- full capacity of system could be achieved even when supply of wood fuel is disrupted
- applicable to larger scale systems
- does not require any conceptual breakthroughs

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Disadvantages / Barriers Common to All Configurations

- 3 types of barriers: technological, market, policy

- added complexity and higher capital costs compared to systems fueled with only natural gas
- difficulties of dealing with a solid fuel
- wood supply uncertainty -- Is it sustainable?
- technological immaturity / risk
- assistance will be required for scale-up and commercialization

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Disadvantages / Barriers Common to All Configurations (cont.)

- lack of tax incentives, tradable credits
- market uncertainty -- Is the market big enough to drive development?
- difficult to permit
- potential users aren't experienced with power generation, will have difficulty developing such complex projects

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Disadvantages/Barriers Unique to #1 Wood Gasification Fuel Cell

- redesign of fuel cell required
- near-term development of fuel cells is focused on other fuels; this system is far in future
- stringent gas cleanup requirements
- less tolerant of disruptions in wood supply
- limited process technology from which to benchmark
- specific feed preparation requirements

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Disadvantages/Barriers Unique to #2 Wood Gasif. Gas Engine / Microturbine

- cleanup required for wood-derived fuel gas (tars, condensable gases, particulates)
- specific feed preparation requirements

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Disadvantages/Barriers Unique to #3 Wood-Fired Gas Turbine Preheat System

- a wood-fired FBC-HX would have to be developed
- corrosion problems in the FBC-HX
- the preheat temperature will be limited by materials

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Prioritization of Needed R&D

- **Assumes $60 million over next 5 years**
- **Factors Considered During Prioritization**
  - Breadth of Application (Crosscutting)
  - Cost-Effectiveness (Bang for the Buck)
  - Level of Risk / Probability of Success
  - Timeliness (Window of Opportunity)
- **Methodology of Prioritization**
  - Multivoting

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Top 10 R&D Needs for Hybrid Wood Energy Systems

Crosscutting R&D needs are orange.

10a. development of low-cost, reliable, automated feed preparation & handling systems

10b. government supported demos, information dissemintation

8. R&D to make systems mobile / modular (if wood supply runs out, system can be moved)

6a. development of an automated fuel gas / natural gas mixer

6b. better interconnection standards

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Top 10 R&D Needs for Hybrid Wood Energy Systems (cont.)

5. development of a fuel cell designed for a wood-derived fuel gas
4. development of a high-temperature, wood-fired FBC air heater
3. development of a low-cost wood gasifier
2. low-cost fuel gas cleanup (particulates, tars, alkalis, sulfur, halides)
1. market assessment of wood supplies, applications and value of various tax policies

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Additional R&D Needs for Hybrid Wood Energy Systems

- a study of possible policies that monetize externalities
- education of public
- a manual that provides guidance on how to develop a hybrid wood energy project
- continued development of high-temperature fuel cells
- an analytical study of mixing natural gas with wood-derived fuel gas

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